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(54) Title: IMPROVEMENTS IN AND RELATING TO OPTICALLY READABLE DISCS AND DISC RECORDING APPARATUS

(57) Abstract

An optical disc and an optical disc recording apparatus have been disclosed, which provide an improved protection against undesired or illegal copying. Information on optical discs is arranged in sectors, which each has an address label. The address value of the address labels increases linearly from the start of the disc or from the start of the program area of the disc. The address labels of specific sectors, which may have an informationless content, are given different, e.g. zero, address values, which prevent copying CD-ROM discs on a standard CD-Recorder apparatus. Said address labels may be stored in the main data stream or e.g. the subcode channel of a CD system.

Layout of copy-protected CD-ROM

Address	Header	Size	Size	Content	Comments
000000		1	0	None	
000001		1	0	None	
000002		1	0	None	
000003		1	0	None	
000004		1	0	None	
000005		1	0	None	
000006		1	0	None	
000007		1	0	None	
000008		1	0	None	
000009		1	0	None	
00000A		1	0	None	
00000B		1	0	None	
00000C		1	0	None	
00000D		1	0	None	
00000E		1	0	None	
00000F		1	0	None	
000010		1	1	None	First address value in CD-ROM
000011		1	1	None	
000012		1	1	None	
000013		1	0	None	
000014		15	1	None	
000015		16	1	None	
000016		17	1	None	None
000017		18	1	None	None
000018		19	1	None	None
000019		20	1	None	None
00001A		21	1	None	None
00001B		22	1	None	None
00001C		23	1	None	None
00001D		24	1	None	None
00001E		25	1	None	None
00001F		26	1	None	None
000020		27	1	None	Address 000027 writing
000021		28	1	None	Address 000028 writing
000022		29	1	None	Address 000029 writing
000023		30	1	None	
000024		31	1	None	None
000025		32	1	None	None
000026		33	1	None	None
000027		34	1	None	None
000028		35	1	None	None
000029		36	1	None	None
00002A		37	1	None	None
00002B		38	1	None	None
00002C		39	1	None	None
00002D		40	1	None	None
00002E		41	1	None	None
00002F		42	1	None	None
000030		43	1	None	None
000031		44	1	None	None
000032		45	1	None	None
000033		46	1	None	None
000034		47	1	None	None
000035		48	1	None	None
000036		49	1	None	None
000037		50	1	None	None
000038		51	1	None	None
000039		52	1	None	None
00003A		53	1	None	None
00003B		54	1	None	None
00003C		55	1	None	None
00003D		56	1	None	None
00003E		57	1	None	None
00003F		58	1	None	None
000030		59	1	None	None
000031		60	1	None	None
000032		61	1	None	None
000033		62	1	None	None
000034		63	1	None	None
000035		64	1	None	None
000036		65	1	None	None
000037		66	1	None	None
000038		67	1	None	None
000039		68	1	None	None
00003A		69	1	None	None
00003B		70	1	None	None
00003C		71	1	None	None
00003D		72	1	None	None
00003E		73	1	None	None
00003F		74	1	None	None
000030		75	1	None	None
000031		76	1	None	None
000032		77	1	None	None
000033		78	1	None	None
000034		79	1	None	None
000035		80	1	None	None
000036		81	1	None	None
000037		82	1	None	None
000038		83	1	None	None
000039		84	1	None	None
00003A		85	1	None	None
00003B		86	1	None	None
00003C		87	1	None	None
00003D		88	1	None	None
00003E		89	1	None	None
00003F		90	1	None	None
000030		91	1	None	None
000031		92	1	None	None
000032		93	1	None	None
000033		94	1	None	None
000034		95	1	None	None
000035		96	1	None	None
000036		97	1	None	None
000037		98	1	None	None
000038		99	1	None	None
000039		100	1	None	None
00003A		101	1	None	None
00003B		102	1	None	None
00003C		103	1	None	None
00003D		104	1	None	None
00003E		105	1	None	None
00003F		106	1	None	None
000030		107	1	None	None
000031		108	1	None	None
000032		109	1	None	None
000033		110	1	None	None
000034		111	1	None	None
000035		112	1	None	None
000036		113	1	None	None
000037		114	1	None	None
000038		115	1	None	None
000039		116	1	None	None
00003A		117	1	None	None
00003B		118	1	None	None
00003C		119	1	None	None
00003D		120	1	None	None
00003E		121	1	None	None
00003F		122	1	None	None
000030		123	1	None	None
000031		124	1	None	None
000032		125	1	None	None
000033		126	1	None	None
000034		127	1	None	None
000035		128	1	None	None
000036		129	1	None	None
000037		130	1	None	None
000038		131	1	None	None
000039		132	1	None	None
00003A		133	1	None	None
00003B		134	1	None	None
00003C		135	1	None	None
00003D		136	1	None	None
00003E		137	1	None	None
00003F		138	1	None	None
000030		139	1	None	None
000031		140	1	None	None
000032		141	1	None	None
000033		142	1	None	None
000034		143	1	None	None
000035		144	1	None	None
000036		145	1	None	None
000037		146	1	None	None
000038		147	1	None	None
000039		148	1	None	None
00003A		149	1	None	None
00003B		150	1	None	None
00003C		151	1	None	None
00003D		152	1	None	None
00003E		153	1	None	None
00003F		154	1	None	None
000030		155	1	None	None
000031		156	1	None	None
000032		157	1	None	None
000033		158	1	None	None
000034		159	1	None	None
000035		160	1	None	None
000036		161	1	None	None
000037		162	1	None	None
000038		163	1	None	None
000039		164	1	None	None
00003A		165	1	None	None
00003B		166	1	None	None
00003C		167	1	None	None
00003D		168	1	None	None
00003E		169	1	None	None
00003F		170	1	None	None
000030		171	1	None	None
000031		172	1	None	None
000032		173	1	None	None
000033		174	1	None	None
000034		175	1	None	None
000035		176	1	None	None
000036		177	1	None	None
000037		178	1	None	None
000038		179	1	None	None
000039		180	1	None	None
00003A		181	1	None	None
00003B		182	1	None	None
00003C		183	1	None	None
00003D		184	1	None	None
00003E		185	1	None	None
00003F		186	1	None	None
000030		187	1	None	None
000031		188	1	None	None
000032		189	1	None	None
000033		190	1	None	None
000034		191	1	None	None
000035		192	1	None	None
000036		193	1	None	None
000037		194	1	None	None
000038		195	1	None	None
000039		196	1	None	None
00003A		197	1	None	None
00003B		198	1	None	None
00003C		199	1	None	None
00003D		200	1	None	None
00003E		201	1	None	None
00003F		202	1	None	None
000030		203	1	None	None
000031		204	1	None	None
000032		205	1	None	None
000033		206	1	None	None
000034		207	1	None	None
000035		208	1	None	None
000036		209	1	None	None
000037		210	1	None	None
000038		211	1	None	None
000039		212	1	None	None
00003A		213	1	None	None
00003B		214	1	None	None
00003C		215	1	None	None
00003D		216	1	None	None
00003E		217	1	None	None
00003F		218	1	None	None
000030		219	1	None	None
000031</					

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Improvements in and relating to optically readable discs and disc recording apparatus.

The invention relates to disc recording apparatus for recording digital data on an optically readable disc. The invention further relates to optically readable discs on which such digital data have been recorded, and playback apparatus for such discs.

5

A system using an optically readable digital audio disc (referred to as a compact disc) is a disc system which can reproduce high quality stereophonic musical sounds. Such system is known from the International Standard IEC 908: "Compact Disc Digital Audio System". Digital data such as data representative of characters, display data, 10 program software, computer data, images, etc. other than stereophonic musical sounds can be stored on and reproduced by such a disc system without markedly modifying the arrangement of the player for such disc. A playback apparatus for reproducing visual information such as charts and statistics using graphics, pictorial illustration using still pictures, and a video game apparatus by adding a display unit, have been realized thereby 15 providing a wide range of use for a compact disc system. The data memory capacity of the current compact disc is about 640 Mbytes, and therefore, a compact disc has a very large advantage as compared with the memory capacity of a standard flexible disc. Such CD systems are known as the CD-ROM system and are known amongst others from the ECMA standard - 130 and 168 respectively: "Data Interchange on Read Only 120mm Optical Data 20 Disks (CD-ROM)" and "Volume and File Structure of Read only and Write Once Compact Disc Media for Information Exchange" respectively.

A drawback of the optically readable discs is that they can be copied easily. Although there is a copy protect bit used in each group of frames of a CD-Audio disc in the subcode channel, still undesired copying is possible, because this bit has a fixed 25 repetitive position in the bitstream provided by the output of the decoder in a CD-player, and thus can easily be "overruled". Further, software programs for PC applications etc. are distributed by use of CD-ROM discs in vast amounts. Here again it is highly desirable that copying can not be done without permission/authorization. Also a lot of other formats of optically readable discs are gaining commercial interest and thus anti-copy mea-

highly desirable.

5 It is an object of the invention to provide an optically readable disc, which has an improved protection against undesired or illegal copying by use of an optical disc recording apparatus. It is a further object of the invention to provide an optically readable disc for any type of compact disc system, which has an improved protection against undesired and or illegal copying of such discs by use of CD-recording apparatus, which are already available in the market.

10 It is another object of the invention to provide an optical disc recording apparatus, which has an improved capability to prevent undesired and or illegal copying of optically readable discs in addition to the todays anti copy mechanisms.

15 According to a first aspect of the invention there is provided an optically readable disc comprising digital data being arranged in sectors corresponding to a unit of organisation of the digital data and each sector being accessible via an address label stored with said sector, characterized in that the address label has an address value increasing with each successive sector except for at least one address label, which has a address value different from the increasing address value. This has the advantage, that such address values cannot be created using a standard optical recording apparatus.

20 A preferred embodiment of the optically readable disc, wherein the digital data comprises digital mainstream data and digital subcode data, is characterized in that the address label having said different address value is stored in the digital subcode data. This is advantageous in that the subcode data cannot be controlled directly on a recording apparatus.

25 A further embodiment of the optically readable disc is characterized in that the address label having said different address value is stored with a sector containing informationless data. This has the advantage, that no special reading device is needed for reading the sectors having the different address values.

A further embodiment of the optically readable disc is characterized in that said different address value is a zero address value.

30 A further embodiment of the optically readable disc is characterized in that a multiple of successive address labels have said different address value.

A further embodiment of the optically readable disc, wherein the sectors are arranged in a program starting with a pregap, rising sectors with informationless data, is characterized in that at least one address label having said

address value, is arranged in the pregap.

A further embodiment of the optically readable disc, wherein the sectors are arranged in a program area preceded by lead-in area and succeeded by a lead-out area, is characterized in that at least one address label having said different address value is arranged 5 in the lead-in area and/or the lead-out area.

A further embodiment of the optically readable disc is characterized in that at least one address label which has said different address value is arranged preceding or succeeding a sector storing copy-protectable information.

A further embodiment of the optically readable disc, on which the digital 10 data is stored according to predetermined modulation and error correction rules, is characterized in that at least one sector comprises at least one error effected by violating the predetermined modulation and error correction rules.

According to a second aspect of the invention there is provided an optical disc recording apparatus for recording digital data on an optically readable disc, the digital 15 data being arranged in sectors and each sector being addressable via an address label, which address label has an address value increasing with each successive sector, characterized in that the optical disc recording device comprises reading means for reading address labels, detection means for detection of an address label, which has a address value different from the increasing address value relative to the address value of the preceding address label, and 20 abortion means for aborting the recording of digital data upon detection of said address label, which has said different address value.

According to a third aspect of the invention there is provided an optical disc playback apparatus for retrieving digital data from an optically readable disc, the digital data being arranged in sectors and each sector being addressable via an address label, 25 characterized in that the optical disc playback device comprises verification means for verifying an address label, which has an address value different from the address value increasing relative to the address value of the preceding address label, and abortion means for aborting the playback of digital data in dependence upon the verification.

30

The invention will be illustrated, by way of an example, with reference to the drawings, in which

Figures 1 and 2 are schematic diagrams which are used to describe the data arrangement of the recorded data on an optical disc to which the invention is applied;

Figure 3 is a schematic diagram showing the arrangement of one block of the digital main data in one embodiment of this invention;

Figure 4 is a block diagram of apparatus in accordance with this invention;

5 Figure 5 is a schematic diagram showing a word format of serial data produced in this apparatus;

Figure 6 shows a schematic diagram of the layout of a CD-ROM disc as a function of time;

10 Figure 7 shows in a matrix a schematic diagram a table of addresses, sector numbers, tracks and content of CD-ROM disc as a function of time in accordance with the invention;

Figure 8 shows a schematic diagram of the layout of the sector organisation of a another optical disc; and

15 Figure 9 shows schematically an optical disc recording apparatus in accordance with the invention.

Figure 1 shows the data stream recorded on a compact disc. One frame Fr consists of 588 bits of recorded data, and each frame has at its head a frame sync pulse FS 20 of a specific bit pattern. The frame sync pulse FS is followed by a 3-bit DC-restriction word RB. Thereafter, the 0th - 32nd data words DB each having 14 bits and the 3-bit DC-restriction words RB are further recorded alternately. The 0th words among these data words DB are subcode data (or so-called user bytes) of a subcode signal which is used to control the playback of a disc and to display the relating information or the like. In the audio 25 disc format, the 1st to 12th and 17th to 28th data words DB are assigned for audio data in the main channel. The remaining 13th to 16th and 29th to 32nd data words DB are assigned for parity data of the error correction code in the main channel. Each of the data words DB consists of 14 bits into which 8-bit data has been converted by a 8 to 14 conversion upon recording.

30 Figure 2 shows the state of data in one group of the frames (98 frames), with the 98 frames arranged sequentially in parallel. In Figure 2, each of the data words D3 is represented by 8 bits and the DC-restriction words RB are excluded. The subcode signal data F + W in the 0th and 1st frames form the sync patterns which are predetermined bit patterns. In the Q channel, the CR is for error detection and in the latter 16

frames among the 98 frames.

The P-channel signal is a flag to indicate a music program and a pause. With music recorded in audio disc format, this signal in the P-channel has a lower level throughout the duration of a music program and a higher level throughout the duration of a pause, and has pulses of 2-Hz period in the lead-out section. It is possible to select and play back the specified music program by detecting and counting this signal in the P channel. The Q channel enables more complicated control of this type. For example, when the Q-channel information is stored in a microcomputer in the disc playback apparatus, it is possible to shift quickly from one music program to another during the playback of a music program; thus, 10 respective ones of the recorded music programs may be selected at random. The other R through W channels can be used to indicate an author or composer, an explanation, poetry, or the like for the music programs recorded on the disc.

Among the 98 bits in the Q channel, the first two bits are used for a sync 15 pattern; the next four bits for control bits; then the next four bits for address bits; the following 72 bits for data bits; and at last a CRC code for error detection is added. A track number code TNR and an index code X are included in 72 bits representative of the data bits. The track number code TNR can be varied from 00 to 99, and the index code X can be likewise changed from 00 to 99.

20 Furthermore, the data in the Q channel contains a time indication code representative of the time durations of music programs and pauses, and a time indication code indicative of an absolute time duration that continuously changes from the beginning to the end on the most outer rim side in the program area of the compact disc. These time indications codes comprise the codes indicating minute, second and frame which each consist 25 of two digits. One second is divided into 75 frames. In order to access digital data from the compact disc on a shorter unit basis than a music unit, the time indication code with respect to the above-mentioned absolute time duration is used in this embodiment of the present invention.

Figure 3 illustrates an arrangement of digital signals other than 30 stereophonic musical signals from the compact disc in an embodiment of the present invention. As described above, the subcode signal for a compact disc is organised in units of 98 frames. In this embodiment of Figure 3, one block of the main data is constituted by the length of 98 frames corresponding to the same group of the 0th to 97th frames. In the audio format, one frame in the digital audio data consists of 12 words each of :

and so 24-byte digital main data can be inserted in one frame. Referring to Figure 3, one row contains total 32 bits of one sample in the L channel of the audio data and one sample in the R channel thereof, and each frame consists of six such rows.

5 In the embodiment of Figure 3, a one-bit sync bit is added to the head of each 32-bit row of the block. In the 0th frame F₀ the sync bits at the respective heads of the first 32 bits and the next 32 bits are zero. The sync bits in each head of the respective first 32 bits in the frames bearing even numbers except the 0th frame are zero, while the sync bits in each head of the respective first 32 bits in the frames bearing odd numbers are one. These sync bits enable the detection of the head location of the block on a 98-frame unit basis.

10 The above-mentioned one block consists of (24 bytes x 98 = 2352 bytes). The data of 2 Kbytes (2048 bytes) is inserted in one block, and 304 bytes (2432 bits) remain. (6 x 98 = 588 bits) are used as sync bits. A 7-bit mode signal and a 24-bit address signal are inserted in the first 32 bits in the 0th frame, so that 1813 bits still remain in one block. These 1813 bits can be assigned to redundant bits when the 15 error correction coding processing is performed for the data of one block.

15 The mode signal serves to specify the kind of data in that block. For example, the mode signal is used to discriminate character data, still picture data and program code. The address signal serves to specify the data in the block. Furthermore, the reason why the sync bits of the frame bearing even numbers are set to zero is that the 20 present embodiment of the invention takes account of an arrangement of data block on a two-frame unit basis. For the block having a size of two frames, a mode signal and an address signal are added to each block. In the case of the block having a length of 98 frames as in the Figure 3 embodiment of this invention, the codes for indicating the P data and the absolute time durations of the Q data in the subcode signals in the same 25 block are identical.

The digital signals in the block format shown in Figure 3 can be recorded on a compact disc in the same manner as an audio compact disc. That is, a digital signal to be recorded is supplied to a digital input terminal of a digital audio processor and this digital signal is converted into a video signal format, thereby recording it using a VTR system of 30 the rotary head type. In this case, TOC (table of contents) data to generate a subcode signal is preliminarily recorded in the audio track in the starting edge section on a magnetic tape on which this digital signal will be recorded. Next, the TOC data reproduced from this magnetic tape is supplied to a subcoding generator, and the reproduced digital signal is supplied to an encoder and the subcode signal is then supplied to this encoder, then a laser beam is

modulated on the basis of an output of the encoder. A master disc is made by means of this modulated laser beam.

As another method of recording a digital signal, the data stored on, for example, a hard disc memory that can be accessed at a high speed is accessed by a 5 minicomputer, and a digital signal is supplied in real time to an encoder of a cutting system.

Figure 4 shows a playback apparatus in accordance with this invention. In Figure 4, reference numeral 1 denotes a compact disc on which a digital signal of the above-described format has been spirally recorded. The compact disc 1 is rotated by a spindle motor 2. In this case, the spindle motor 2 is controlled by a spindle servo circuit 3 so that the compact disc 1 rotates at a constant linear velocity.

Reference numeral 4 indicates an optical head, which has a laser source for generating a laser beam for pickup, a beam splitter, an optical system such as an objective lens or the like, and a photoreceptive device for receiving the reflected laser beam from the compact disc 1, etc. The optical head 4 can be moved in the radial direction of the compact disc 1 by the thread feed motor 5. The thread feed motor 5 is driven by a thread drive circuit 6. The optical head 4 can be deflected both in the direction perpendicular to the signal surface of the compact disc 1 and in the direction parallel thereto, and it is controlled so that the focusing and tracking of the laser beam upon playback are always properly performed. For this purpose, a focusing and tracking servo circuit 7 is provided.

20 A reproduction signal from the optical head 4 is supplied to an RF amplifier 8. The optical head 4 is provided with a focus error detecting section consisting of a combination of, for example, cylindrical lens and 4-dividing detector, and a tracking error detecting section using three laser spots. This servo error signal is supplied to a focusing and tracking servo circuit 7. An output signal of the RF amplifier 8 is supplied to a digital demodulator 9 and a bit clock reproduction circuit 10. The digital signal recorded on the compact disc 1 has been EFM modulated. The EFM modulation is a method of block-converting 8-bit data into a preferable 14-bit (i.e. 14 bits such as to provide a long minimum inverting time period of the modulated signal and reduce its low-frequency component) pattern. The digital demodulator 9 is constituted in such a manner as to carry out 25 the demodulation of EFM. The bit clock fetched by a bit clock reproduction circuit 10 is supplied to the digital demodulator 9 and the spindle servo circuit 3.

operation, the reading operation of the optical head 4, or the like are controlled by the system controller 11. Control commands are supplied to the system controller 11 through an interface 17, that will be described later. Namely, the reading operation of a desired digital signal from the compact disc 1 using the subcode signal is controlled by the system controller 11.

The main digital data output from the digital demodulator 9 is supplied through a RAM controller 12 to RAM 13 and an error correction circuit 14. The processing with respect to the elimination of variation of the time base, error correction and error interpolation are carried out by the RAM controller 12, RAM 13 and error correction circuit 14, so that the digital main data is fetched from terminals 15L and 15R. In the case of playback of a compact disc on which only audio data has been recorded, D/A converters would be connected to these terminals 15L and 15R, respectively. In the case of Figure 4, no D/A converter is provided to fetch the digital data from the outputs, and the reproduced digital data is supplied to a data converter 16. The reproduced subcode signal is also supplied to this data converter 16, and the reproduced data is converted into the form of a serial signal.

This serial signal is supplied to the interface 17, and the data for the system controller 11 is supplied from a microcomputer system 18 through the interface 17 to the controller 11. The microcomputer system 18 specifies a readout address and applies control signals such as start signals in addition to this readout address to the interface 17 and system controller 11. A list of a plurality of record areas has been recorded in the lead-in track in the most inner rim section on the compact disc 1 using the subcode signal as addresses. This list is reproduced in the initial state to start the readout of the compact disc 1 and is read by the microcomputer system 18.

Figure 5 shows an example of the word format of the serial signal output from the data converter 16. For this serial signal, one word consists of 32 bits; the first four bits are for preamble; next four bits for auxiliary bits of the audio data; and next 20 bits for digital audio sample. In the case where the digital audio sample consists of 16 bits, 16 bits from the least significant bit (LS8) are inserted. Four bits are added after the digital audio sample. Among these four bits, the first bit indicated by V is a flag to show whether the digital audio sample of that word is effective or not; bit U is each bit of the subcode signal; bit C is a bit to identify the channel; and bit P is a parity bit. This bit U of the subcode signal is inserted into each word format one bit by one and these inserted bits are sequentially transmitted.

In one embodiment of the present invention, a read instruction to a predetermined address is first executed by the microcomputer system 18. This address is a code itself for indicating an absolute time duration in the Q channel and is supplied through an interface 17 to the system controller 11. The system controller 11 controls the thread 5 drive circuit 6 to move the optical head 4 to the location near a desired pickup location while supervising the subcode signal reproduced by the optical head 4. In this example, therefore, the reproduction is started from the location spaced a few blocks apart to prevent a malfunction due to the access operation being not finished if an error occurred in the reproduced subcode signal and the set subcode signal is not reproduced. The desired block is 10 caught by detecting the coincidence of the reproduced subcode signal with the designated address, or by starting the playback from the location near the correct subcode signal and then counting the frame sync signals.

In fig. 6 a schematic layout of a CD-ROM disc in accordance with the invention has been shown. Reference is made herewith to the ECMA-Standard 130 (CD-ROM-Standard) Section IV: Recording, which is incorporated in here for purpose of 15 reference.

The information area IA on a disc comprises at least a lead-in area LI, a program area PG and a lead-out area LO. The track number TNO, which is recorded in the Q-channel of the subcode channel, has the value OO and AA respectively for the lead-in area 20 LI and the lead-out area LO respectively.

The program area PG has been divided in a plurality of tracks. In this example the CD-ROM disc comprises CD-Audio tracks as well as CD-ROM data tracks. The four tracks as shown have the successive track numbers, 01, 02, 03 and 04 and are an audio track, a ROM track, a ROM track and an Audio track respectively. The index belonging to 25 track number TNO, each time has the value 00 during a pregap, which comprises informationless data e.g. the value 00 (in Hexadecimal notation). The index has the value 01 during the groups of frames (sectors) comprising information such as audio or ROM DATA.

In the subcode data time references have been recorded. A first time reference TIME relates to the information in the track. Each time at the start of the 30 information in a track the time reference TIME starts at a value zero and increases linearly with the successive groups of frames in a track. Further the time reference TIME starts at a certain value at the start of a pregap and decreases linearly with the successive groups of frames, which comprise informationless data (e.g. "digital silence"), and ends at the value zero at the end of the p

Further an absolute time code ATIME has been recorded in the Q channel of the subcode data. This absolute time code ATIME has a zero value at the beginning of the program area PG and increases linearly with the groups of frames in the program area PG. In accordance with a first embodiment of the invention in the pregap 1 there have been 5 recorded absolute time codes that do not comply with the linear increasing values of ATIME, e.g. the value zero can be recorded as indicated by zero sector address ZSA1.

The ROM data in the CD-ROM tracks (TNO = 02 or TNQ = 03) are accessible by address labels that have been recorded in the main stream data. These ROM-Sector Header Addresses have the same value as the absolute time code ATIME in the Q 10 channel corresponding to the same sectors (groups of frames) as shown in figure 6. In another embodiment of the invention certain ROM Sector Header Addresses have been set to zero beyond pregap 2, TNO = 02; INDEX = 01. Again this is a violation of the linearly increasing absolute time code ATIME and the ROM Sector Heading Addresses corresponding therewith.

15 In fig. 7 a table of sector addresses ADD, sector numbers SN, track numbers TNO, index numbers INDEX and content has been shown. The sector address 00:00:00 first occurring in the very first address of the Program Area PG (see Fig. 6). The sector addresses ADD increases linearly during the 150 sector of the pregap. (from 00:00:00 to 00:00:74 for the first 75 sectors and from 00:01:00 to 00:01:74 for the second 75 sectors).
20 The first part of the CD-ROM track 1 comprises sectors, which may comprise information start at sector SN=0 at address 00:02:00. In accordance with the invention sectors 27, 28 and 29 each have an address ADD equal to 00:00:00, which violates the linear increasing sequence of addresses. The content of the sectors 27, 28, 29 are informationless. These sectors 27, 28 and 29 have been preceded by sectors that do have information, e.g. sectors
25 16 and 17 contain the Primary Volume descriptor for this CD-ROM discs. The sectors SN = 18 to SN = 74 do not have information and are not referred to in the directory of the CD-ROM. Sector SN = 75 and succeeding sectors up to 355.349 provide the CD-ROM user data, which end at the postgap of sectors 355.350 to 355.499. The next sector is the start of the lead-out area, which is shown by track number TNO = AA.

30 In fig. 8 another embodiment of a layout of an optically readable disc in accordance with the invention has been shown. The disc shows an information area, a lead-in area and a lead-out area. The lead-in area comprises several blocks, each comprising the same number of sectors (e.g. a block comprises 16 sectors). A number of Start Blocks SB all con contain informationless data. Re end blocks RB may contain information for

error correction of the Start Blocks SB. Intermediate Blocks IB1 again may comprise informationless data. In a next part of the Lead-In Area several control blocks CB are present, which may comprise information about the disc, discmanufacturer etc. Intermediate Blocks IB2 follow the Control Blocks CB, precede the Data Area DA and comprise 5 informationless sectors. Sector number addresses start with address $SN = 0$ at start of the lead-in area and end with address $SN = n$ for the last sector of the lead-out area. The sector addresses increase linearly from 0 to n for each sector therebetween, except for a few sectors in e.g. intermediate blocks IB1 or IB 2. These few sectors have sector address labels, which have an address value different from the increasing value, e.g. a zero address value. As a 10 result undesired copying is prevented.

It should be emphasized that the sector addresses, which should violate the linear increasing sequence of the address values can be arranged at random in the specified areas, so as to increase the threshold of undesired/illegal copying of discs.

Fig. 9 by way of example shows an embodiment of an information 15 recording device in accordance with the invention. The present embodiment is a recording device by means of which information can be recorded on a record carrier 91, for example an optical record carrier, which is rotated about an axis 92. The information recording device comprises a customary read/write head 93, arranged opposite the rotating record carrier 91. By means of a customary positioning system for example in the form of a motor 94 and a 20 spindle 95a, the read-write head 93 can be moved in a radial direction relative to the record carrier 91 under control of a customary control unit 95, which comprises for example a microprocessor.

An information signal Vi to be recorded can be applied to a signal 25 processing circuit 97 via an input 96. The signal processing circuit 97 is of a customary type, which converts the applied input signal into a recording signal Vop is applied to a driver circuit 98 of a customary type, which converts the recording signal Vop into a drive signal Vs for the read/write head 93 in such a way that an information pattern corresponding to the recording signal Vop is recorded on the record carrier. For the purpose of reading the recorded information patterns the read/write head 93 has an output for supplying a read 30 signal $V1$ which is representative of the information pattern being read. The read signal $V1$ is applied to a read circuit 99 for recovering the information presented by the read signal $V1$. The driver circuit 98 is of an adjustable type, enabling one or more of the parameters with which the quality of the recorded information pattern can be influenced to be adjusted. When 35 optical read/write head 93 is read by which an information pattern of optically detectable

effects is formed by means of a radiation beam, the intensity of the radiation beam is an important parameter which largely dictates the quality of the information pattern. If the read/write head is a magnetic or magneto-optical write head which generates a magnetic field for the purpose of forming an information pattern in the form of magnetic effects (domains),

5 the field strength of the generated magnetic field may be an important adjustment parameter. If the information patterns is formed by means of write pulses the pulse width may be an important adjustment parameter. It is to be noted that the above-mentioned adjustment parameters are only few examples of the large number of adjustment parameters which are possible. In this respect reference is made in particular to NL-A-9000150 (PHN 13.217), in

10 which the adjustment parameter is a reference value for the speed with which the effects are formed at the adjusted reference value.

For determining the optimum setting of the driver circuit 98 the device comprises an analysis circuit 910, which derives from the read signal an analysis signal V_a which is indicative of the quality of the information pattern being read. The optimum setting

15 can be determined in a calibration procedure by forming test information patters for different settings of the driver circuit on the record carrier 91 and by selecting on the basis of the analysis signal V_a that setting for which the analysis signal indicates an optimum quality. In principle, the information signal V_i may be employed for writing the test information pattern. However, it is also possible to employ a test signal generator 911 for this purpose, which

20 may then be included, for example, in the signal processing circuit 97. The optimum setting is determined under control of the control unit 915, which for this purpose is coupled to the analysis circuit 910, to the driver circuit 98, and to the test signal generator 911, if present, which control unit is loaded with a suitable program or comprises a suitable hardware circuit. Preferably, the optimum setting is determined in a calibration procedure, which is

25 carried out after a record carrier has been inserted in the information recording device.

Further the information recording device has a digital input 96D for receiving digital signals D_i in accordance with international Standards or de-facto standards, such as CD-Audio Signals, CD-ROM signals etc. This input 96D is connected directly to the input of driver circuit 98, because the digital signals are alike to the digital recording signal

30 V_{op} generated by the processing circuit 97.

The digital input signal D_i is further read by reading means 97A, which read the address labels either from the digital main-stream data or from the subcode data and provides the same to the detection means 97B. Upon detection by the detection means 97B of an address label having a zero value in succession of an address label having a non-

zero address value the detection means 97B trigger abortion means 97C, which aborts recording of the digital input signals D_i by setting the driver circuit 98 into a non-operative condition. Preferably the means 97A, 97B and 97C and the driver circuit 98 are integrated in a single integrated circuit.

5 The playback apparatus according to the invention is arranged for retrieving the digital data from the optical disc as described with Figure 4. Before the user actually is given access to the digital data, a verification process is executed. The presence of at least one of the address labels having said different address value is verified, e.g. by reading the sector of which the address label is known to be different. If the reading response shows an error, the 10 presence of the different address value is detected, and if the response shows a normal sector, the different address value is absent. The value of the address label may also be verified directly by reading means arranged for reading the address label, such as described above with Figure 9. In dependence upon the verification the playback of the digital data is aborted, i.e. in the case that one or more of the different address values are absent. Illegal copies of 15 the optical disc may comprise some or all digital data of the sectors having the normal, increasing address values. However the illegal copies will not have the sectors having address labels with said different address values, as such labels cannot be recorded using standard recording equipment. The verification may be a build in verification procedure in the playback apparatus, e.g. verifying some sectors with fixed addresses. Alternatively the 20 addresses of sectors to be verified may be stored on the optical disc in a normally readable sector. However in a preferred embodiment of the playback apparatus, the verification procedure is part of the digital data stored on the optical disc and is loaded from the optical disc in a programmable part of the playback apparatus when the optical disc is entered in the apparatus. For an optical disc comprising computer software, e.g. a CD-ROM, the 25 verification procedure preferably is an integral part of the computer software the user will activate.

In a further embodiment of the optically readable disc at least one sector is provided with other errors instead of or in addition to said different address value. In a CD the channel code EFM is used as described above with Figure 4. The errors may be effected 30 by modifying the EFM channel bit patterns into non permitted patterns of channel bits or by violating other modulation or error correction rules. For example for EFM a minimum (d) and maximum (k) number of channel bit periods between each transition of logical value is given, the so called d,k constraint. If the d,k constraint is violated, the EFM decoder certainly will report e. reading device will pr . read error message v

reading such a sector having errors, and a standard recording device cannot record such errors. In a preferred embodiment the sectors comprising other errors are arranged adjoining sectors having only the different address value, as it will be difficult to detect which are the sectors having the different address values and which are the sectors comprising the other errors, as the reading will be influenced by the combined effects of the adjoining sectors.

5 A malicious party faces various difficulties in creating an operative illegal copy. The playback apparatus is not able to read the sectors having said different address values and/or the sectors comprising the other errors, and will generate read errors. A recording apparatus may be forced by the malicious party to replace such sectors by dummy sectors.

10 10 However a standard recording apparatus cannot create the different address values or the other errors, while in operation the absence thereof will be detected on the playback apparatus. Modifying the standard recording device to create said different address values is difficult. Modifying the standard recording device even further to create the other errors is even more difficult. Therefore in practical circumstances an operative copy cannot be made.

CLAIMS:

1. An optically readable disc comprising digital data being arranged in sectors corresponding to a unit of organisation of the digital data and each sector being accessible via an address label stored with said sector, characterized in that the address label has an address value increasing with each successive sector except for at least one address label, which has a address value different from the increasing address value.
2. An optically readable disc as claimed in claim 1, wherein the digital data comprises digital mainstream data and digital subcode data, characterized in that the address label having said different address value is stored in the digital subcode data.
3. An optically readable disc as claimed in claim 1 or 2, characterized in that the address label having said different address value is stored with a sector containing informationless data.
4. An optically readable disc as claimed in claim 1 or 2, characterized in that said different address value is a zero address value.
5. An optically readable disc as claimed in claim 1, characterized in that a multiple of successive address labels have said different address value.
6. An optically readable disc as claimed in claim 1, wherein the sectors are arranged in a program area starting with a pregap comprising sectors with informationless data, characterized in that at least one address label having said different address value is arranged in the pregap.
7. An optically readable disc as claimed in claim 1, wherein the sectors are arranged in a program area preceded by lead-in area and succeeded by a lead-out area, characterized in at least one address label having said different address value is arranged in the lead-in area and/or the lead-out area.
8. An optically readable disc as claimed in claim 1, characterized in that at least one address label which has said different address value is arranged preceding or succeeding a sector storing copy-protectable information
9. An optically readable disc as claimed in claim 1, on which the digital data is stored according to predetermined modulation and error correction rules, characterized in that at least one sector contains at least one error and by violating the pre-
ed

modulation and error correction rules.

10. An optical disc recording apparatus for recording digital data on an optically readable disc, the digital data being arranged in sectors and each sector being addressable via an address label, which address label has an address value increasing with
5 each successive sector, characterized in that the optical disc recording device comprises reading means for reading address labels, detection means for detection of an address label, which has a address value different from the increasing address value relative to the address value of the preceding address label, and abortion means for aborting the recording of digital data upon detection of said address label, which has said different address value.

10 11. An optical disc playback apparatus for retrieving digital data from an optically readable disc, the digital data being arranged in sectors and each sector being addressable via an address label, characterized in that the optical disc playback device comprises verification means for verifying an address label, which has an address value different from the address value increasing relative to the address value of the preceding
15 address label, and abortion means for aborting the playback of digital data in dependence upon the verification.

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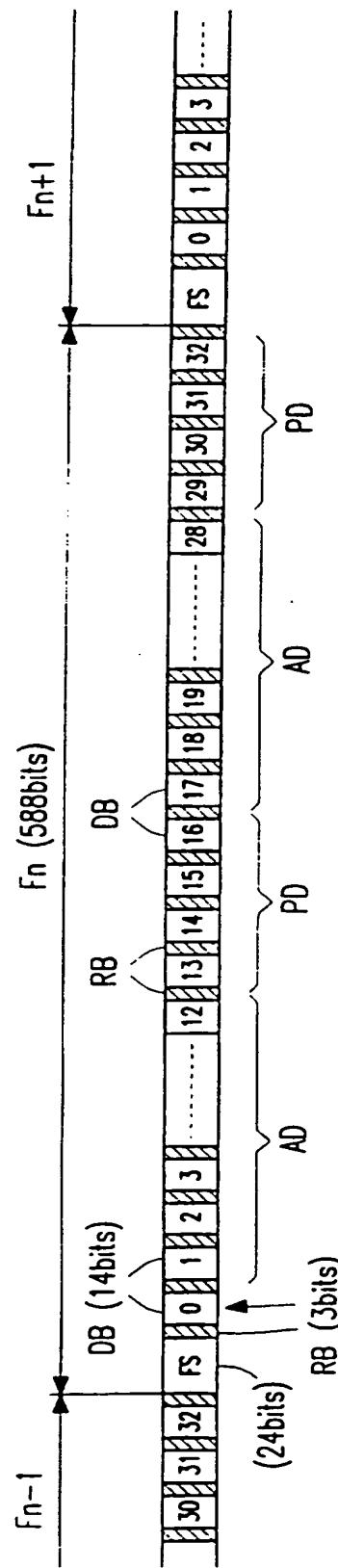


FIG. 1

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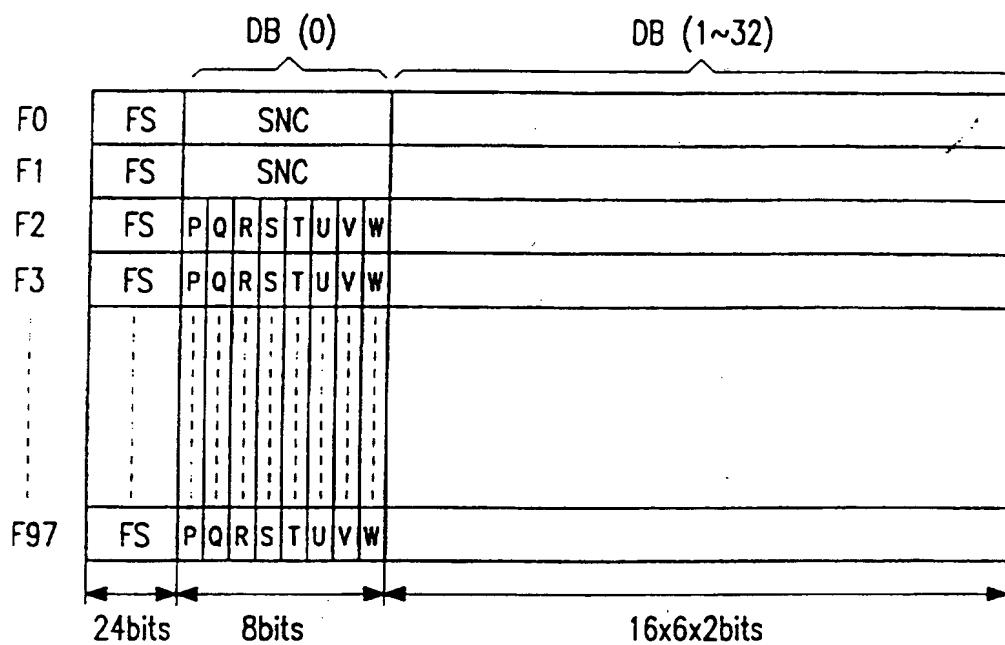


FIG. 2

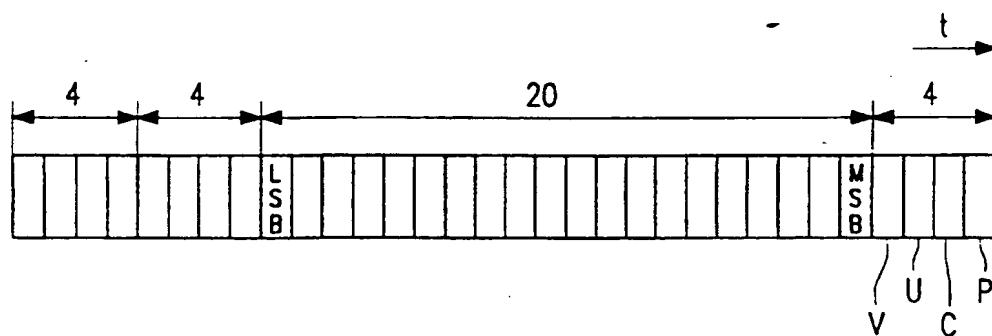


FIG. 5

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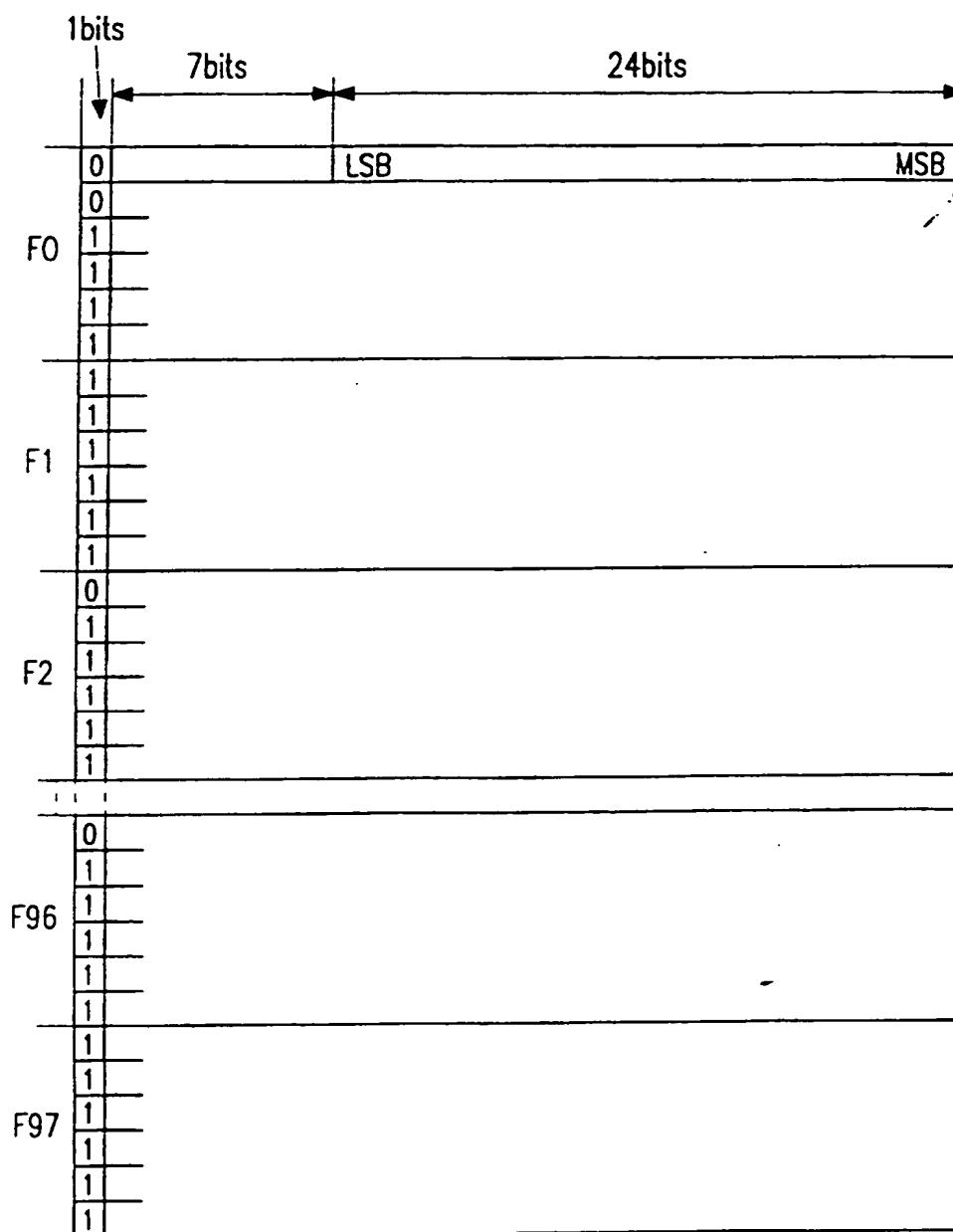
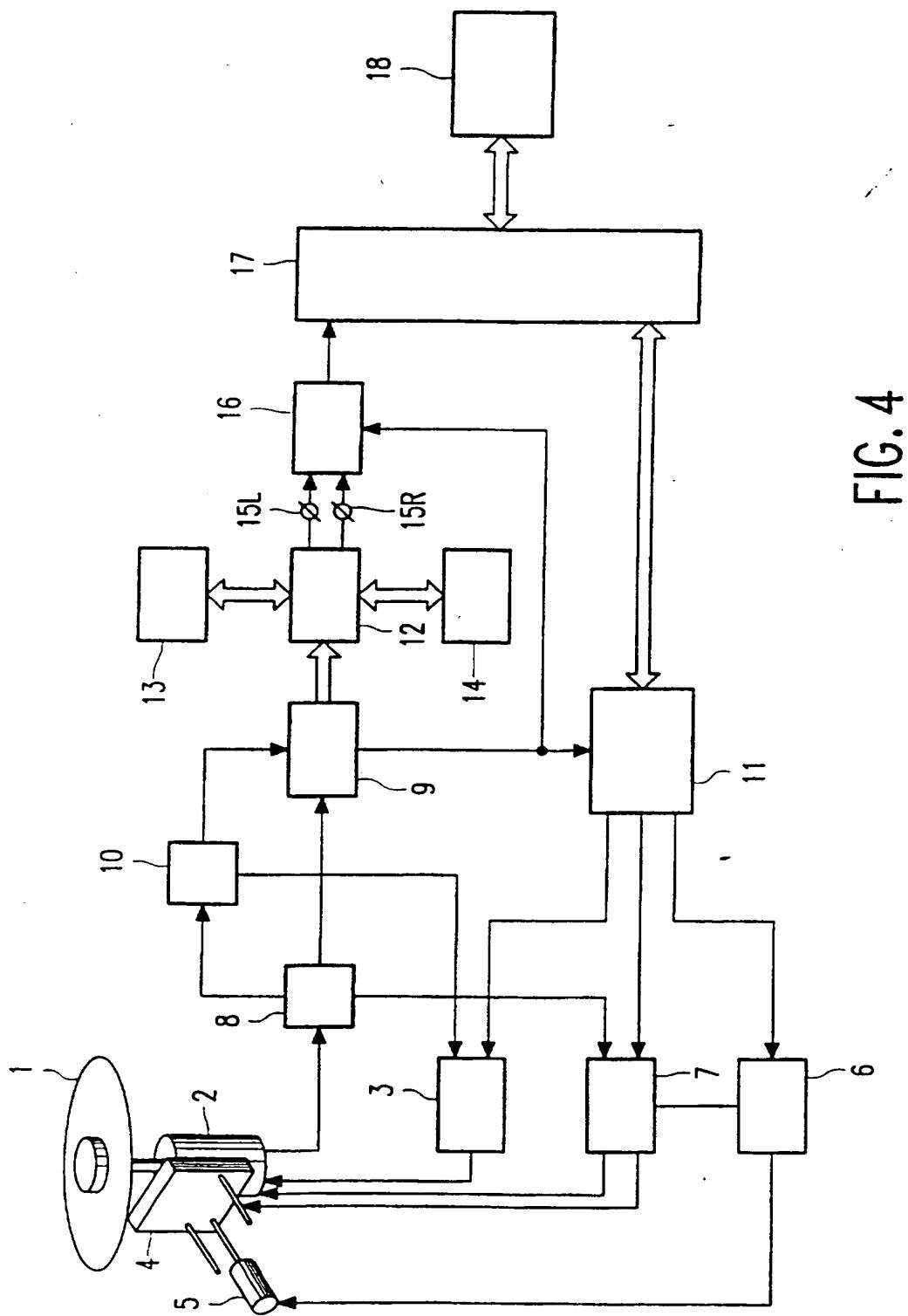


FIG. 3

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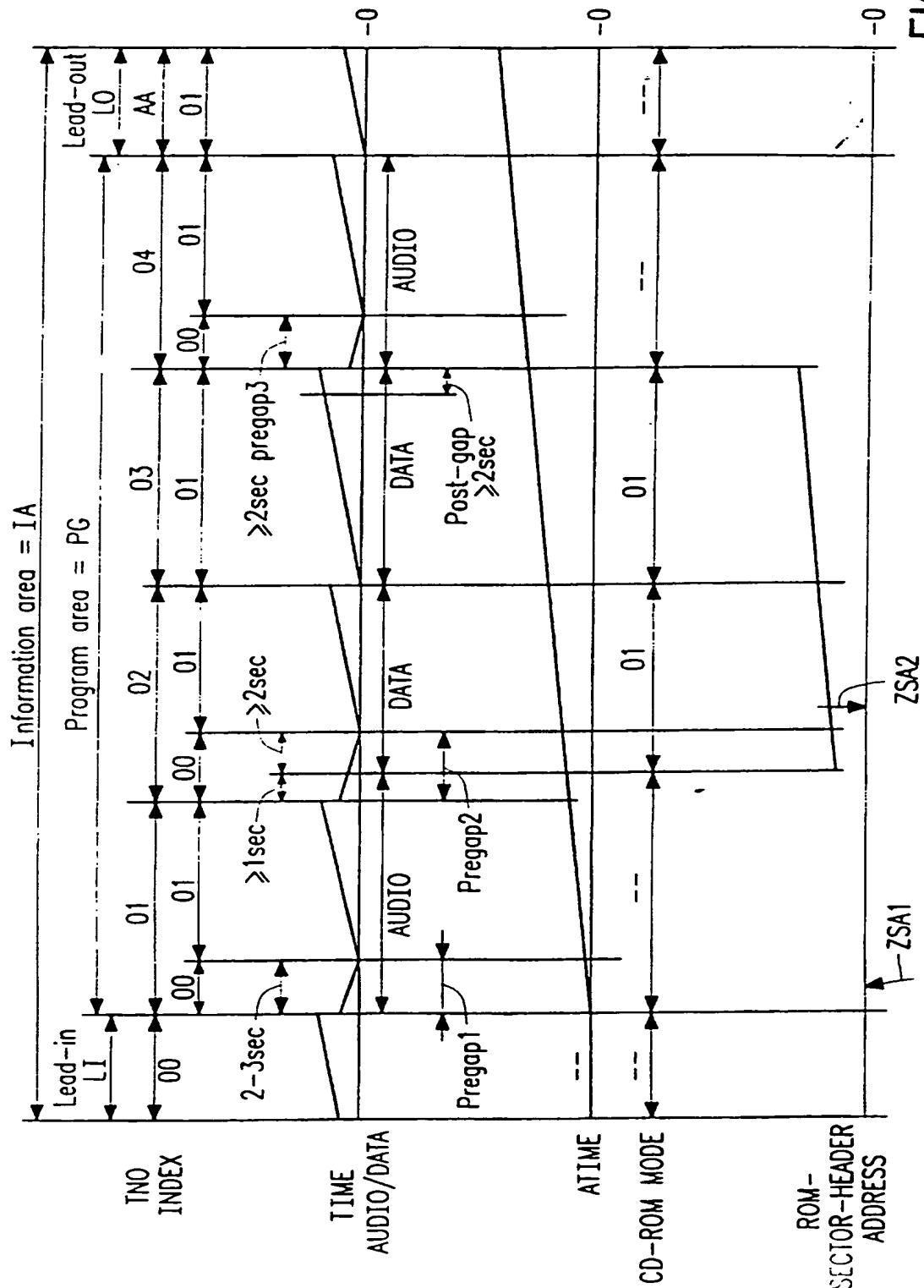


FIG. 6

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Layout of copy-protected CD-ROM

Address	Sector	Track	Index	Content	Comments
00:00:00		1	0	Zeros	Start of 150 sectors Pregap
00:00:01		1	0	Zeros	
00:00:02		1	0	Zeros	
-----		1	0	Zeros	=
00:00:74		1	0	Zeros	
00:01:00		1	0	Zeros	
00:01:01		1	0	Zeros	
00:01:02		1	0	Zeros	
-----		1	0	Zeros	=
00:01:73		1	0	Zeros	
00:01:74		1	0	Zeros	
00:02:00	0	1	1	Zeros	First readable sector on CD-ROM
00:02:01	1	1	1	Zeros	
00:02:02	2	1	1	Zeros	
-----		1	0	Zeros	=
00:02:15	15	1	1	Zeros	
00:02:16	16	1	1	PVD	Primary Volume Description
00:02:17	17	1	1	PVD	Primary Volume Description
00:02:18	18	1	1	Zeros	No reference to these sectors
-----		1	0	Zeros	= in the directory of the CD-ROM
00:02:24	24	1	1	Zeros	
00:02:25	25	1	1	Zeros	
00:02:26	26	1	1	Zeros	
00:00:00	27	1	1	Zeros	Address 00:02:27 missing
00:00:00	28	1	1	Zeros	Address 00:02:28 missing
00:00:00	29	1	1	Zeros	Address 00:02:29 missing
00:02:30	30	1	1	Zeros	
00:02:31	31	1	1	Zeros	
00:02:32	32	1	1	Zeros	
-----		1	0	Zeros	=
00:02:73	73	1	1	Zeros	No reference to these sectors
00:02:74	74	1	1	Zeros	in the directory of the CD-ROM
00:03:00	75	1	1	Data	User data
00:03:01	76	1	1	Data	User data
00:03:02	77	1	1	Data	User data
00:03:03	78	1	1	Data	User data
-----		1	1	Data	= User data
78:59:73	355348	1	1	Data	User data
78:59:74	355349	1	1	Data	User data
79:00:00	355350	1	1	Zeros	Postgap
-----		1	1	Zeros	= Postgap
79:01:74	355499	1	1	Zeros	Postgap
79:02:00	355500	AA		Zeros	Start Leadout, End of CD

ADD ↑ SN ↑ TNO! ↑ INDEX ↑

FIG. 7

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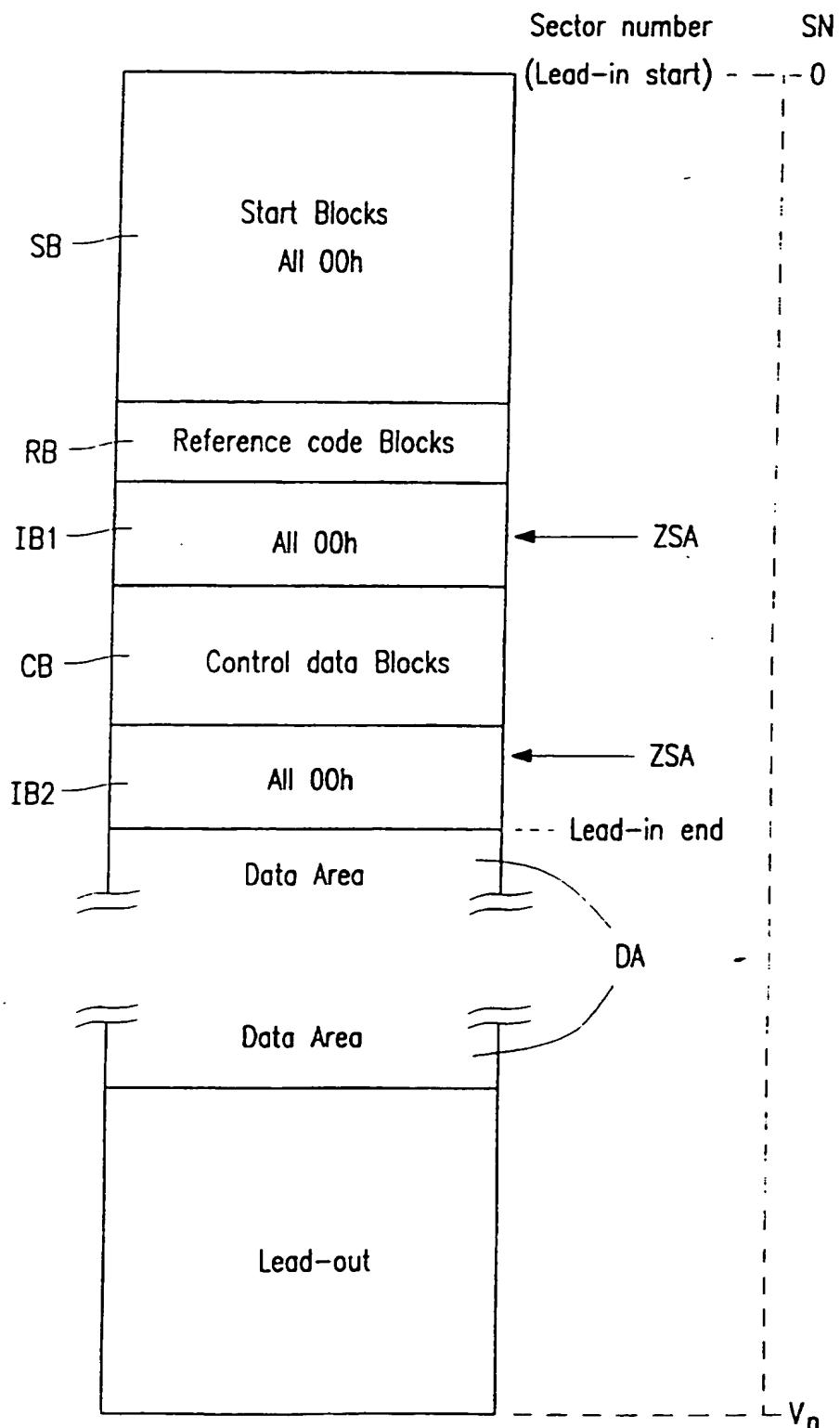


FIG. 8

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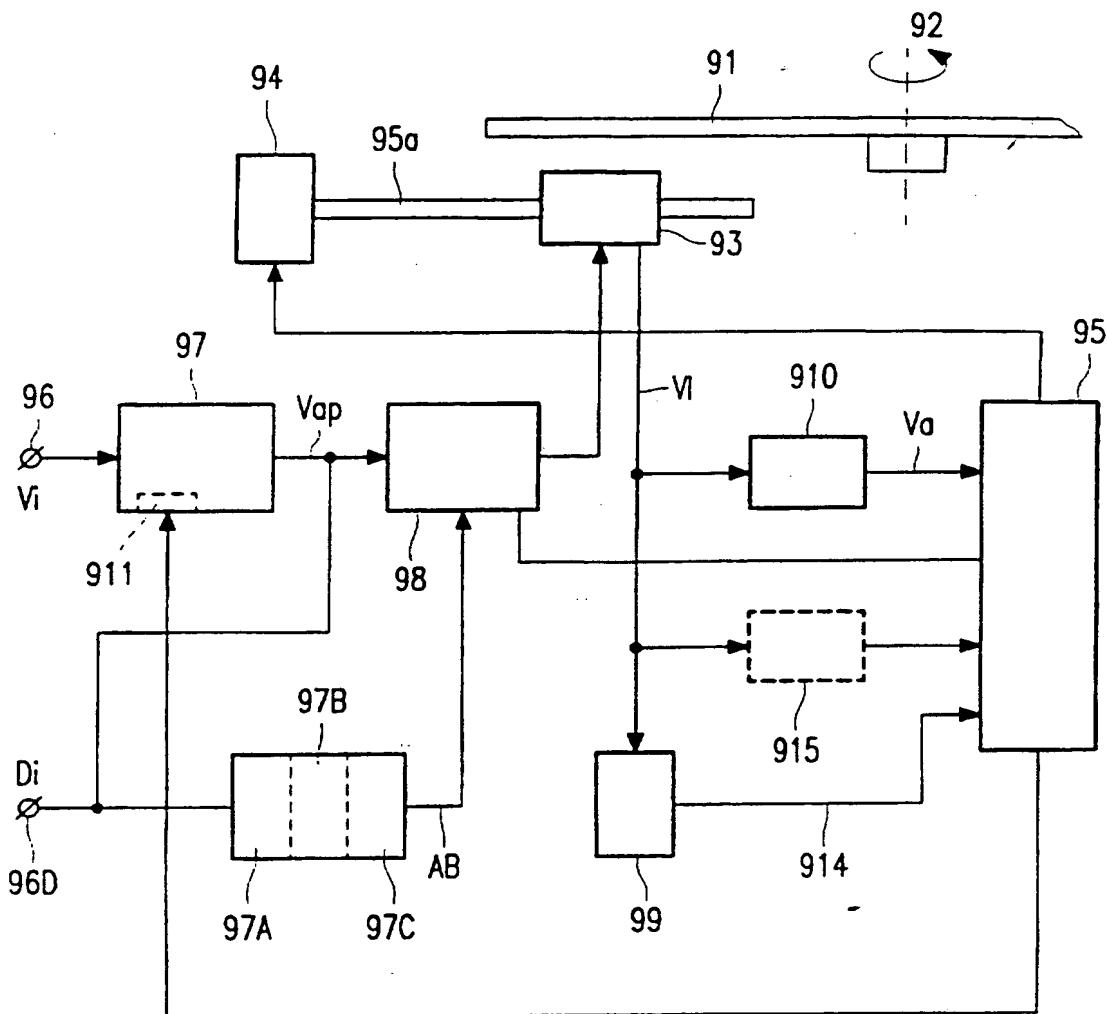
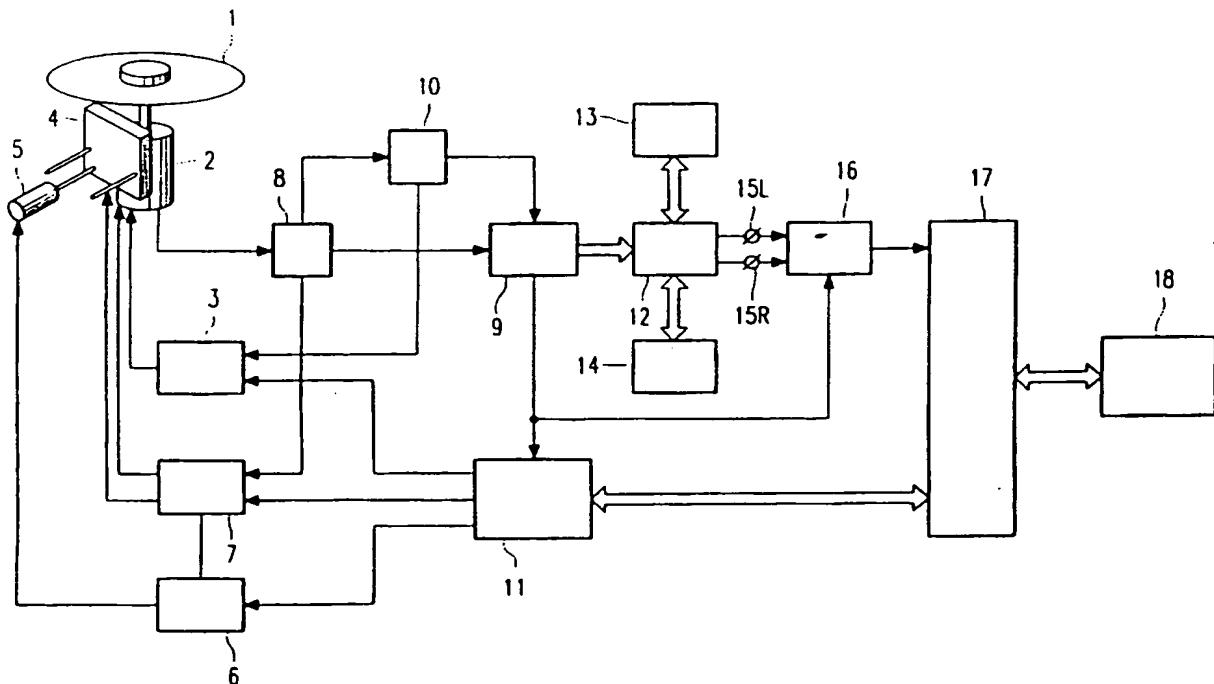


FIG. 9

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(54) Title: IMPROVEMENTS IN AND RELATING TO OPTICALLY READABLE DISCS AND DISC RECORDING APPARATUS



(57) Abstract

An optical disc and an optical disc recording apparatus have been disclosed, which provide an improved protection against undesired or illegal copying. Information on optical discs is arranged in sectors, which each has an address label. The address value of the address labels increases linearly from the center of the disc or from the start of the program area of the disc. The address labels of specific sectors, which may have an information, are given different, e.g. zero, address values, which prevent copying. The optical discs on hard CD-Recorder apparatus, the address labels may be stored in the run-in stream or e.g. the subcode channel system.

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1
INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 97/00867

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G11B 7/007, G11B 20/10, G11B 27/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPAT, WPI, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0686968 A2 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD), 13 December 1995 (13.12.95), column 19, line 30 - line 42; column 20, line 19 - column 21, line 16, abstract	1-2, 10-11
Y		3
A	--	4-9
X	EP 0674316 A2 (SONY CORPORATION), 27 Sept 1995 (27.09.95), page 5, line 57 - page 6, line 15; page 21, line 16 - line 53, abstract	1-2, 10
A	--	3-9, 11

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Date of the actual completion of the international search

27 January 1998

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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